## IV. *On the Reversion and Restoration of the Silkworm.* By Captain Thomas Hutton, F.G.S., of Mussooree, N. W. India. (Communicated by Mr. Frederic Moore.)

[Read 2nd May, 1864.]

### *Introductory Remarks.*

For many years past the utmost anxiety has prevailed on the European Continent, and more especially in France, in regard to the condition of the common silkworm, known to science as the *Bombyx Mori*, the constitution of the worm appearing to be so thoroughly weakened and undermined, by diseases arising from a long and uniform course of domestication, bad nourishment and other prejudicial influences, as to excite the most lively apprehensions lest the insect should suddenly become extinct.

That such apprehensions are far from groundless may be seen in the fact that one form of disease by which the worm is attacked, known in France as "*la muscardine*," is said by M. Guérin-Ménéville annually to destroy more than *one-fourth* of the worms; and it has been clearly shown by this eminent Entomologist, and by several experienced cultivators of silk, that the crop has, within the last ten years, dwindled down to about one-half of what it used to be.

Various remedies have, of course, from time to time been tried for the purpose of arresting the progress of disease, sometimes with partial and temporary effect, but more generally without any success at all.

In consequence of these maladies, and their inability to arrest them, the French, with prudent and praiseworthy foresight, are using every possible means to introduce and acclimatize other species, which may, in some measure, fill the commercial void which would be created by the loss of the common silkworm.

Under these circumstances it occurred to me, that while assisting our continental neighbours in the introduction of such wild species as occur within our Western Himalayan forests, I might as well at the same time endeavour if possible to reclaim and restore to health the most valuable species of the whole; and, consequently, for several years past I have studied and experimented upon the *Bombyx Mori* and its domesticated congeners, with a degree of success which I now purpose to unfold.

In experimenting upon the worm I have not confined my efforts within the narrow limits of an endeavour to cure particular phases of disease, but to effect a permanent benefit in the restoration of a healthy and vigorous constitution, which, if accomplished, as I think it may be, will of itself not only cast out this or that particular phase of disease, but all the diseases under which the worm is now labouring; and I am fully convinced that until such radical change has been wrought, it will be but time and labour thrown away to seek to cure particular maladies as they appear.

Hitherto the results of my experiments have been such as to warrant my entertaining the most sanguine hopes of ultimate success, provided the same system be carried on for a few years longer, when it will of course depend upon the cultivator to maintain the advantages thus secured.

Of all the groups comprised within the family of the *Bombycidæ* that in which the genus *Bombyx* is contained, is, perhaps, in a commercial point of view, the most interesting and the most valuable. This genus contains, besides a few wild indigenous species widely scattered over the continent of India, all those long domesticated species popularly known as "*silkworms*," which were centuries ago imported into Europe from the northern provinces of China, where for many centuries previously they had likewise been kept in a state of domestication.

Having, however, already, in a paper entitled "Notes on the Silkworms of India," entered somewhat fully into the history of the Chinese species, I need not here travel over the same ground, but shall call attention to facts not previously noticed, and endeavour, after exposing the folly of insisting, as some still obstinately do, upon the healthy and vigorous constitution of the insects, to show by how very simple a method the worms may be induced to *revert* from their present artificial and moribund condition to one of vigour and permanent health.

### *Discovery of the Silkworm.*

According to the commonly received chronology the discovery of the silkworm in China was made about the year B.C. 2640; and the means of reeling off, or unwinding the fibre from the cocoon, being also discovered, the regular domestication of the insect at once commenced.

Whether the species then discovered was, in reality, that to which naturalists have since assigned the name of *Bombyx Mori*, or whether the discovery of more than one species then occurred, we have now no means of positively ascertaining; nor, indeed, does it

much signify, as for the present, at least, it is with that known and cultivated in Europe as an annual that we have to deal; but from a paragraph quoted by Mr. F. Moore from the "Account of the Ceremonies of the China Dynasty," it would appear as if more than one species was under cultivation at the time when the "Account" was written, inasmuch as it contains an allusion to a second crop of silk, when it says,—"the officer who adjusted the price of horses forbad the people to rear a second breed of silk-worms in one season." Now, whatever the *Bombyx Mori* may be when cultivated in Cashmere, Persia or Europe, it may undoubtedly be made, in a suitable temperature, to produce an autumnal brood; this, however, refers to the worm after having been submitted to my experiments for two or three years, and when, indeed, it may be said to be fast travelling back to a state of nature. The same thing occurs likewise with regard to another species which is also an annual, as far as I can learn, in all countries, except Mussooree, in the Western Himalaya; this is the *Boro Pooloo* of Bengal, and *Bombyx textor* (nobis), which, like the *Bombyx Mori*, yields an autumnal crop when treated in a particular temperature. This fact, indeed, has led some people to declare that the two are but varieties of the same species, and that in a state of domestication all may, by the application of certain temperatures, be made to yield several crops of silk annually. This, however, may fairly be denounced as pure nonsence, the occurrence of the two crops arising solely out of the fact of our having in autumn a recurrence of the spring temperature, or what may be called a double season. Hence, since a particular degree of temperature causes the egg to hatch, whenever the season returns in which that temperature is produced, the young worm is of course excluded from the egg. It is quite possible then, and even probable, that these species may originally have done the same in their native country, and the reason why they have ceased to be double-brooded in Europe and other localities is to be attributed solely to the uncongenial temperature, which is sometimes too high, at other times too low; and with respect to those species which are termed "monthly" worms, if it were really the case that the number of crops is due to cultivation in warm climates, it ought to follow that, when domesticated in a cold climate, the frequent succession of silk crops should become less frequent, and the worm give symptoms of reverting to its old habits. Such, however, I have not found to be the case; for although I have succeeded in obtaining two broods from *Bombyx Mori* of Cashmere and *B. textor* of China, yet the small monthly China worm

(*B. Sinensis*, nob.) has continued yielding crop after crop even to the middle of December, when the eggs were again deposited in a temperature of 53° of Fahrenheit. Hence I adhere with good reason to the opinion that all are naturally distinct species. Consequently, as all the other accounts, quoted by Mr. Moore and other authorities, lead to the conclusion that one spring crop only was produced by the worm originally cultivated in China, it will be well to allow the annual species domesticated in Europe as *B. Mori*, to retain that distinctive title, more especially when we consider that as the people were forbidden to rear—not merely *a second crop of silk*, but—"*a second breed of worms*," the stock, if double-brooded, would speedily have been destroyed and lost by such interdiction. This, then, would tend to prove that the worm under cultivation was an annual only, and that the prohibition extended to other species.

*Introduction into Europe.*

From the year before Christ 2,640 until 550, or thereabouts, of the Christian era, the domestication of the worm appears to have been exclusively confined to China, severe punishments being inflicted upon any one who ventured to attempt its exportation into other countries, when, at length, about the latter year, through the laudable zeal of missionary monks who had visited China and there learnt the mode of cultivation, the eggs were secretly conveyed into Europe and presented to the Emperor Justinian.

*Constitution impaired by Domestication.*

Thus, for a period of more than 3,000 years, the so-called cultivation of the worm had remained exclusively in Chinese hands. What wonder, then, if the constitution of the insect had during that time been gradually undermined by a course of imperfect feeding, close and tainted atmosphere and various other enervating causes, until, at length, when imported into the West, it no longer retained its natural vigour, health and original characteristics, but had become enfeebled, degenerated and sluggish, by a long system of interbreeding with debilitated stock, and rendered liable, by the loss of constitution, to a multitude of diseases!

From the time of its introduction into Europe, the treatment it has experienced has been, with some modifications, nearly the same as that pursued in China; so that for an uninterrupted period of no less than 4,500 years, the worm has had to contend against all those unnatural and purely artificial influences arising from a state of domestication, which we erroneously persist in

terming *cultivation*, without one single renewal or infusion of the original healthy and natural stock from which the race has descended! Truly has it, as Darwin would say, undergone "the struggle for existence!"

One would almost be tempted to think, that the object of cultivators had actually been the destruction of the insect, for in what other department would breeders so long have neglected to infuse new blood into their domestic stock? Is it not a well understood and long-established fact, that, whether among animals or plants, an occasional renewal of seed and re-infusion of the original stamina is found to be absolutely necessary for the preservation of health, and of that particular standard of perfection which it is thought desirable to maintain? And yet with the domesticated *Bombyx Mori*, this necessary precaution has been uniformly neglected for 4,500 years! What wonder, then, that under the combined effects of bad and scanty food, want of sufficient light and ventilation, too high a temperature, and with the constant and unvarying interbreeding of a debilitated stock, the insect should have become subject to a multitude of maladies, and threaten, at no distant period, to become extinct!

By here condemning the system of interbreeding, I must, however, guard against the possibility of being misunderstood, for I am well aware that in France a very senseless outcry has been raised in some quarters against the interbreeding of brother and sister, and other near relatives, as if, in a state of natural freedom, such a proceeding was not the general and authorized rule. What I condemn, and in this I am happy to find myself supported by such weighty authority as that of M. Guérin-Ménéville, is not the intercourse of near relations, but the incessant interbreeding of diseased and debilitated individuals, which, as "like produces like," cannot possibly do otherwise than perpetuate and aggravate both disease and debility. Where brothers, sisters and cousins are all healthy and of sound constitution, no bad consequences will ensue from their interbreeding, for such is the established plan upon which nature acts; but where disease exists, the breeding from two deteriorated individuals, whether they be nearly or distantly related, will only add fuel to the fire, and perpetuate, and even aggravate, disease.

I assert, then, that there is no such thing now in existence as a perfectly healthy domesticated stock of silkworms, the colour proving, beyond all doubt, that the constitution has been utterly destroyed, and the wonder rather is, that the worms have continued to live so long, and to yield such good returns under such

a constant struggle against adverse circumstances; for it seems quite evident, since naturalists have never recorded the colours of the caterpillar to be otherwise than ashy or creamy-white, that even so long ago as the time of the Emperor Justinian, the true colour of the worm had already been obliterated by the centuries of mismanagement to which the Chinese had subjected the insect. It is true that the occasional occurrence of dark-coloured worms among the general brood has been observed, yet these occurrences are always spoken of as exceptional cases indicating variety arising from domestication, rather than as denoting, what in reality is the fact, an attempted return, on the part of nature, to the original colours and characteristics of the species.

Under no other supposition than this does it appear possible to account for the error committed by the older naturalists; and, consequently, I again assert, with the greatest confidence, and shall presently prove, that the whiteness of the worm is to be regarded solely as a positive indication of the loss of constitution, and that the species, in its natural colours, has yet to be described.

*The Fruitlessness of seeking for healthy Seed.*

I shall probably be told that learned and experienced men have occasionally been sent from Italy and France, in order to collect fresh seed (as it is termed) for the purpose of renovating the sickly stock of Europe by the re-infusion of a healthier and more vigorous constitution from the worms of India and of China. Such an assertion, to a certain extent, would, no doubt, be true, since it cannot be denied, that a search for healthier stock has often been made, though never with success, from the simple fact, that whether in Europe, Persia, India or China, the worms are all equally degenerated, or if indeed there be a difference yet perceptible, it is altogether in favour of the European race. We can all "call spirits from the vasty deep—but will they come when we do call?" Had a search been instituted in China for *the wild worm* in its original state of freedom, great benefit would no doubt have ensued from its discovery; but if we reflect that the worm, even in its native country, has, like that of Europe, been immemorially of a pale colour, a Chinese cultivator on being asked for the original wild stock would at once acknowledge that he knew the worm under no other aspect, and in no other condition, than that in which for so many centuries it had been cultivated by his forefathers, and the idea of its having possibly

changed or lost its colour under domestication, would in all probability never enter into the head either of the Chinaman or of his interrogator. Seeing then, as I shall presently show, that the Eastern is infinitely inferior to the European stock, the crossing with seed selected either in India or in China would only be adding to the disease which already threatens the West with such disastrous consequences.

*Nature of Experiments explained.*

I may, however, be asked, what proof I can adduce of disease and change of colour? As regards the existence of disease there is no occasion to reply, as the fact is only too well known; but as regards the loss of colour, I have abundant evidence now before me.

All those, indeed, who have had the least experience in the rearing of the silkworm must have perceived the occasional occurrence among the brood of one or more dark-grey or blackish-brindled worms, contrasting strongly and curiously with the pale sickly hue of the majority. These, by the French cultivators, are called "*vers tigrés*" or "*zébrés*," that is, "tiger or zebra striped,' and are regarded as a mere variety. Yet these are, in fact, the original and natural worms!

My attention having long since been arrested by this circumstance, it at length occurred to me to endeavour by a series of experiments to ascertain the cause, my conviction being, either that the species had at some time or other been crossed by another of different colours, and that nature, as sooner or later she always will do, was making an effort to separate them; or that the original colour of the worm had in reality been dark, and an effort was being made to *revert* from a sickly condition to the original healthy starting-point. Acting on this idea, I at once determined to assist Nature by giving her fair play, and, consequently, picked out all the dark-coloured worms and reared them separately, allowing the moths to couple only *inter se*, and the same course was pursued with the white worms.

In the following spring the one batch of eggs produced nearly all dark-brindled worms, while the other produced white ones, sparingly interspersed as before with an occasional dark one; these latter were removed into the dark batch, which was at the same time weeded of its pale worms.

In the third year the worms were still darker than before, and were always larger and more vigorous than the pale ones, giving likewise larger and better stuffed cocoons.

Unfortunately, just as the eggs of the third year had been deposited and collected, a violent and unexpected gale of wind suddenly upset the whole and irretrievably scattered them abroad. I had, however, seen such good reason for hoping that I might eventually by this method succeed in restoring the constitution of the worm, that I commenced *de novo*, and went over the same ground again.

The eggs with which my experiment was recommenced, were procured in the spring of 1862 from Mr. Cope of Umritsir, in the Punjab, who assured me that they had just arrived direct from Cashmere, although, from their appearance, I strongly suspect they owed "their birth, parentage and education," to the Punjab, and had been sent by mistake. But however this may be, on their arrival at Mussooree, I submitted them to the microscope, which at once proclaimed them to be ill-formed, discoloured and diseased.

This Mr. Cope denied; nevertheless it was a fact, and as the worms proceeded towards maturity, various phases of disease became apparent, and I can only account for the denial of its existence by Mr. Cope and some cultivators in Bengal, by supposing that they do not know a disease even when they see it. The worst form attacked the worms just previous to their spinning the cocoons, and gave them the appearance of having been sprinkled with ink from a pen. This is, I believe, what the French term being "peppered," or "*vers poivrés;*" a most expressive and appropriate term.

Nevertheless the cocoons were formed, though, as might be expected, they were thin, papery and greatly deficient in silk; as cocoons, indeed, they were perfect trash, but, as I had a point to ascertain in respect to the silk, I despatched them to Mr. Turnbull of Ganthal, an experienced and skilful superintendent of silk filatures, ever willing to oblige, and who had likewise reeled for Mr. Cope of Umritsir, and Colonel Clark of Oudh; the result was, that my worthless cocoons yielded a silk not one whit inferior *in quality* to that produced by the inordinately-belauded cocoons of the above-mentioned gentleman; and, indeed, although *in epistolâ* Mr. Cope pronounced Colonel Clark's cocoons to be "the finest he had seen in India," it was declared by Mr. Turnbull, who reeled them, that they had deteriorated 56 per cent. below the Cashmere standard furnished by Mr. Cope himself, and as that standard is itself about 50 per cent. below that of France and Italy, we may safely put down the best Indian cocoons of the true *Bombyx Mori* as being 75 per cent. worse than they ought to

be; and yet, in spite of common sense and twenty-five years' experience, I am modestly required to believe that the worm is not diseased! What then, in such case, is the meaning of the panic in France and Italy?

It is to be remembered, however, that all my sickly worms were of the white variety, and that the few dark worms picked out from them escaped disease altogether, although reared in the same manner, in the same room, in the same temperature, on the same quality of food, and in close contiguity to the others. These dark ones in due time spun cocoons and produced moths, which, coupling *inter se*, deposited a fair stock of eggs, with which the experiment was again carried on in the spring of 1863.

I may here observe that it is a well-known fact that the more numerous are these dark-coloured worms in any brood, the healthier is it considered to be, and *vice versâ*.

Now the eggs furnished by Mr. Cope in the spring of 1862 produced very few dark worms, while the eggs from dark worms descended from them produced in 1863 an undue number of white worms, which had to be weeded out, and proving at the same time the extreme weakness of constitution of the stock upon which I was experimenting.

Again, another proof of disease is found in the fact that in the spring of 1862, the eggs received from Urmitsir were all loose and detached: this is characteristic of the species whether in India or in Europe, and proceeds from weakness in the glands attached to the ovipositor, and which do not, in consequence, secrete the gum necessary to attach the egg. A few will of course always be found to adhere at first, but so slightly that the least touch causes them to fall.

In the spring of 1863 the eggs obtained in the previous year from the dark stock began to hatch on the 16th of March, and no sign of disease was apparent among them until the moths came forth from the cocoons, when many of these still showed defect in the malformation and dark spotting of the wings. As compared, however, with the previous year there was decided improvement; there were still too many white worms in the brood, but they did not show any symptoms of disease and none died; they attained to a larger size by a quarter of an inch, increasing from three to three and a quarter inches in length; they produced, in consequence, larger cocoons, though still deficient in silk, and the moths, although still showing the presence of disease, laid good sized eggs, great numbers of which adhered firmly to the paper upon which they were deposited, and indeed one sheet of paper

was thickly covered with them, a thing which, although I have paid attention to this subject for the last twenty-five years, I never witnessed before, nor even heard of it. The eggs of other species will adhere, but to find those of the *Bombyx Mori* doing so is truly a novelty which betokens decided progress towards a healthier condition.

There was likewise another indication of returning strength to be seen in the fact that, while ordinarily the male moths are so sluggish as to make no attempt to fly, many of those produced from my black stock left the trays and flew off to seek the females in a distant part of the room. This is one of the marked characteristics of the wild moth of *Bombyx Huttoni*, which flies off from tree to tree for long distances when "on amorous thoughts intent."

But still more extraordinary appears the fact that some of the eggs of *B. Mori* of the spring crop of 1863 began to hatch *again for a second crop* on the 7th of August of the same year; these were all from the dark stock, and the circumstance, in itself perfectly novel, arises, I am inclined to think, from an accession of strength acquired by reversion to a state approaching more nearly to the original constitution.

The hatching continued throughout August, and occasionally even to the 23rd of September, when, fearing that my supply of leaves might fail, the eggs were removed to a temperature below 70° Fahrenheit in order to check the hatching.

The worms now hatched continued to grow and thrive, and spun good cocoons superior in size to those of the spring crop, the worms attaining to $3\frac{4}{10}$ inches in length. In due time the moths appeared and were fully twice as large as those of spring, depositing large well-formed eggs. In the beginning of December, to my dismay, more worms were hatched from the spring batch, and continued to come forth throughout the month at the rate of 40 or 50 daily in a temperature of 53° Fahrenheit, when, having no more leaves upon the trees, I was compelled to place the remaining eggs out in the open air at night in order that the sharp hoar frosts might effectually put a stop to any further hatching. All these worms were of the dark kind, and no white ones now appeared among them as in the spring; indeed from the white stock only three worms were produced and these came to nothing. This circumstance, so thoroughly unusual with *Bombyx Mori*, I attribute entirely to an accession of health and strength in the black worms, which are evidently now in a transition state, which may account in some measure for their hatching out of season, so

irregularly and in such a low temperature. This, however, must close the experiment for 1863, and I must hope for some decided results in the spring of 1864 from the eggs deposited in October, 1863.

In the meantime then I will return to the consideration of what the worm ought in reality to be.

### *The Dark Worm is the Natural Colour.*

That the dark colour is the natural one is shown in some measure by the strong similarity, evinced in the disposition and arrangement of the markings, to the wild races of India; while the moth also, instead of remaining so purely white in wings and body, assumes a dark ashy or smoky hue on the body of the males, which is likewise diffused over a great portion of the wings, as in *Bombyx Huttoni*.

Here, then, I think I have already given in the above account strong proofs that the original colour of the worm was dark, and that the pale sickly hue which it has long since assumed is entirely owing to debilitated constitution.

Nor is there here much room for wonder when we reflect how often among our other domestic stock the original colour fades away, to give place to pie-bald, and finally to white. Need I do more than call attention to our domesticated rabbits, our pigeons, domestic fowls, turkeys, Guinea fowls, ducks and geese, in proof that the more the white colour prevails the further do the species recede from their natural characteristics, and the weaker becomes the constitution. Even our cage birds, as every bird-fancier well knows, exhibit this same tendency to lose their original colours, and become paler and paler, until many eventually turn altogether white.

On this subject, for the purpose of strengthening my argument, I feel that I cannot do better than quote a passage from General Daumas' very able work on "The Horses of the Sahara," that writer's views being so thoroughly in accordance with my own.

"It is abundantly apparent," says the General, "that legendary traditions and experience are in perfect harmony in according a decided superiority to coats of deep and decided hues. Coats of a light pale colour are held in no esteem whatever. The horse's coat, therefore, must be an index to his character. The long experience of Mahomed the prophet and of Moussa the conqueror must have placed them in a position to speak with full knowledge of the subject, and their opinion, confirmed by that of all the Arabs, the best horsemen in the world and the most interested in

studying the animal, upon whom indeed depends their honour and their life, is certainly entitled to be regarded with some respect. It is beyond all question that the *Koummite*—red mingled with black, chestnut or bay—is preferred by the Arabs to all others. If I might be allowed to quote my own personal experience, I should have no hesitation in saying that, if there be any prejudice in the matter, I share it with them. Besides, must it necessarily be a prejudice because it may seem to be one? *No one will deny that all the individuals of the same species are, in their wild state, identical in colour and endowed with common instinctive qualities inherent in the race.* These colours and these qualities undergo no alteration or admixture *except in a state of servitude and under its influences, so that if any of these individuals by a return to their natural condition*, more easily proved than explained, *happen to recover the colour of their first ancestors, they will be equally distinguished by more broadly defined natural qualities.* The canine race may be taken as an illustration. Whence it follows that a certain number of domesticated individuals being given, their coats alike and with dominant qualities, it may be fairly concluded that this coat and these qualities were those of the race in its wild state. In the case then of the Arab horse, if it be true that those whose coat is red shaded with black are endowed with superior speed, are we not justified in inferring that such was the uniform colour, such the natural qualities, of the sires of the race? I submit with all humility these observations to men of science.

"Abd-el-Kader assures us, moreover, that it is ascertained by the Arabs that *horses change colour according to the soil on which they are bred.* Is it not possible, in fact, that *under an atmosphere more or less light, of water more or less fresh, of a nurture more or less rich according as the soil on which it is raised is more or less impregnated with certain elements*, the skin of the horse may be sensibly affected? Every one knows that with any coat *the colour changes in tone and shade according to the locality where the animal lives, the state of its health, the quality of the water it drinks, and of the food it eats, and the care that is bestowed upon it.* There is, perhaps, in all this a lesson in natural history not to be despised, for if the circumstances in which a horse lives *act upon his skin, they must inevitably act also in the long run upon his form and qualities.*" *

Truly does the author here remark, that there is "in all this a lesson in natural history not to be despised," though, doubtless, he

* "The Horses of the Sahara," by Gen. Daumas, p. 20. English Translation.

little thought how applicable were his observations to the actual condition of an insect of such value and importance to his own countrymen as the *Bombyx Mori*. I have *italicised* those passages to which I wish more particularly to draw the reader's attention, and shall now proceed to show their applicability to my present subject.

That the long-continued domestication of the silkworm has tended greatly to deteriorate its original constitution, the numerous diseases to which it is now subject, in every country where cultivated, furnish ample proof. That imperfect ventilation of the rearing houses produces a vitiated and impure atmosphere, highly injurious to health; that the nourishment derived from the mulberry leaves will be more or less good according to the condition of the tree from which they are gathered; and that the tree itself will be influenced by the nature of the soil and the temperature of the climate in which it grows, are facts of which every observant cultivator is well aware.

As with the horse, then, so with the silkworm; an unhealthy state of the atmosphere in which it is reared, together with an insufficiently nutritious diet, combined with other disadvantages which are incidental to a state of servility or domestication, must sooner or later exercise a very marked effect upon the general health of the animals, and the constitution, being once impaired, will necessarily, by affecting the animal functions generally, not only act upon the skin and colour, but engender debility and disease.

It is under such circumstances, and when the species threatens to become extinct, that nature's great Guide and Ruler, acting for the creature's good, and with a view to the preservation of the species, invariably makes efforts to restore it to its original characteristics, and these symptoms of *reversion*, if seized and followed up by judicious efforts on the part of man, may enable him, perchance, eventually to cast out disease, and restore the species to its natural colours and original strength of constitution.

Herein consists the entire secret of my experiments with the *Bombyx Mori*. Seeing that a very remarkable difference in colour sometimes occurred, and being fully aware of the truth of General Daumas' remark, that "the colours and the qualities undergo no alteration or admixture except in a state of servitude, and under its influences," I determined to ascertain whether the dark colour of some worms was or was not occasioned by an effort on the part of nature to *revert* to the original point at which

domestication had commenced, and that it actually is such is proved, not only by the colours remaining permanent in the black race, which *they do not in the white race,* but by the acquisition of qualities which originally belonged to the species and which the pale-coloured worms do not exhibit. Thus, as the General truly observes, "the recovery of the colour of their first ancestors has caused them to be distinguished by more broadly defined natural qualities."

Still further, we gather from the observations of M. Boitard, that "the black worm, which is so often met with in the north of France, is absolutely unknown in Italy; and yet the eggs, which in France will produce them, are often purchased in Italy."

Here it is plain, if my views are correct, that climate tells upon the constitution of the insect even in Europe, and that in Italy, where the temperature is high, the black worm is unknown, simply because the heat of the climate, combined, perhaps, with too high a temperature in the houses, enervates the worm and causes it to depart further from its original type than it does in France, where the climate is colder and more favourable to the general health of the insect.

Again, the same writer informs us, that "in Lombardy the worm which produces the white silk will constantly furnish nine white cocoons to one yellow one, although in France, no matter how much care may have been bestowed upon the worm, the yellow cocoons will always far out-number the white ones." Now I have long entertained the idea, that the production of white cocoons is (except in cases where that colour is permanent in all climates) a strong sign of degeneracy, proceeding from weakness of constitution, the rather that such white cocoons are always more abundant where the temperature is high, than in more temperate climates. Hence in Italy the worms, which in that high temperature will constantly produce an excess of white, will in a more favourable situation and circumstances produce an excess of yellow, cocoons. Thus, the *Boro-pooloo* of Bengal (*B. textor*, nob.), which there and in China, as a rule, produces white cocoons, when reared in the colder climate of Mussooree yields almost all yellow cocoons; while to find a white cocoon among the worms of Cashmere (*B. Mori*) is altogether the exception.

Hence I come to the conclusion, that the whiteness of the worm and the white cocoons are both indications of failing constitution, evidencing the existence of a higher temperature and of a more thoroughly artificial treatment than are conducive to the

health of the insect. Were the white or the yellow colour to remain permanent in all climates and temperatures, the fact might reasonably be regarded as a specific character, but where, as in the above observations, we perceive these colours to be dependent upon temperature, we are compelled to regard the change as entirely dependent upon the state of health.

Thus heat, by causing debility, undermines the constitution, and gradually changes the natural colours, of both the insect and the silk secreted by it, into a sickly white, while a restoration to a cooler climate will, under proper management, restore the colours to their natural shade, by imparting vigour to the drooping insect.

### *Deterioration proved.*

Those who possess any real knowledge of the subject under discussion will, I am fully aware, require no further proof of the worm's deterioration than has already been furnished above ; yet as there are not wanting some pretended savans, whose private interests prompt them to conceal as much as possible the maladies under which all our worms are labouring, I shall proceed yet further to show, even from their own arguments, how very little they really know upon the subject.

Common sense will at once point out that a worm imported from the northern provinces of China will not long maintain its vigour in any part of the hot lowland provinces of India, and indeed this is fully shown by one cultivator proposing to preserve the eggs of *Bombyx Mori* by sending them from the Punjab to the mountain station of Durrumsala, as well as by the fact that Jaffer Ali of Mooltan invariably preserves his in a cool underground chamber or *tykhana*.

It is evident from this, that even the heat of the Punjab is far greater than the egg can bear, and if it be inimical and destructive to the egg, it will undoubtedly be equally so to the insect in every other stage. The loss annually sustained by the cultivator Jaffer Ali, even when the eggs are kept in the *tykhana*, is said to be "from a fourth to a third," the heat (even under ground !) drying up the eggs without hatching the worms !* If this can be called successful cultivation then no one need despair !

From this admission it is clear that what actual disease effects in France, where "*la muscardine*" is said annually to destroy more than one-fourth of the worms, is effected by heat, even in an

* Powlett's Report in Proceedings Agricult. Soc. of India, 9th July, 1862.

underground cellar, in the Punjab; how then, in such a climate, can really good results be expected, since the same writer, while trumpeting forth the wonders performed in the Punjab, very naively winds up his laudations with the assurance that "*out of taikhanahs the eggs cannot be preserved in the plains at all.*"

As to his assertion that those eggs "that survive the heat are not injured, but produce as healthy and fine worms as if the eggs had been kept in a cool climate," it actually amounts to nothing, unless at the same time we can feel assured that the writer is well acquainted with what the worms ought to be, and can prove that they are as large and produce the same quantity of silk as those of colder climates; and that such is not the case is proved by the testimony of Mr. C. J. Turnbull, who states that Umritsir-reared cocoons are 56 per cent. below the Cashmere standard!

Indeed this gentleman, who is undoubtedly a good authority, pronounces the cocoons of Oudh and of Umritsir to be about equal, so that they had degenerated in those localities *in one season* 56 per cent. below the standard of Cashmere as furnished by Mr. Cope himself a couple of years before!

Again, cocoons raised at Lucknow in Oudh by Dr. Bonavia required 5,200 to the pound of silk; at Candahar in 1840 the Afghans reckoned about 4,500 to the pound of silk; while in France, previous to the late epidemic, 2,500 cocoons were, on the testimony of Mr. Bashford,* equal to a pound of silk.

Here, then, we have positive evidence that the climate of the Punjab and other parts of the plains of India is injurious to the health and general well-being of the insect.

Now it is also the opinion of Mr. Turnbull that the Candahar and Cashmere yield of silk is pretty nearly on a par; and as from the above statistics the Oudh and Punjab cocoons are at least 50 to 56 per cent. below the Cashmere standard, which is itself considerably below that of France, we may safely say that the cocoons of the Indian-bred *Bombyx Mori* are little short of 75 per cent. below what they ought to be.

What benefit then, I would ask, is likely to ensue from the introduction into Italy of the eggs lately purchased in Cashmere by Dr. Carlo Orio? The worms reared from those eggs will no doubt be improved by the change of climate and more judicious treatment, but they will add nothing to the health and vigour of the European stock!

It has been justly remarked that "there are few individuals

* Journal Hort. Soc. of India, vol. ix. part 3, p. 261.

who have not watched the interesting changes which take place in the larvæ of the *Bombyx Mori*, or common silkworm, from the point of its exit from the egg until it has reached its full butterfly existence; and many there are who have been sadly disappointed at the mortality which comes over a brood of silkworms in a single night from some cause or causes unknown, and consequently irremediable. Such epidemics are continually occurring in China as well as Europe, and constitute one of the greatest obstacles to the introduction of the culture of the silkworm into England. What occasions this sudden decimation of these insects has never been determined, but has long led to a wish, on the part of those interested, that a more hardy breed of silk-producing worms could be introduced into Europe, even though the produce was coarser and of a worse colour than the ordinary mulberry silk."* Here, then, is a further and very recent testimony to the diseased state of the worm.

*Good Quality of the Silk no Proof of general Health.*

I shall doubtless be told that "the proof of the pudding is in the eating," and that as silk of the best quality and worth twenty-five shillings per pound has been produced in the Punjab, the worm cannot possibly be diseased or have lost its constitution.

To this I reply, that in order to test "the pudding" properly and fairly, we require a judge possessed of some knowledge of what a pudding ought to be.

In the introductory remarks to my "Monograph on the Genus *Attacus*," I have shown, after Kirby and Spence and other authorities, that the gum from the reservoirs being conveyed to the mouth by the constriction of certain muscles, passes through two small orifices in the lip, and the two fibres thus formed, being taken up and twisted together by the hook-like processes in the mouth appointed to that office, become one fibre of silk on coming into contact with the cold external air. Now these two orifices in the lip are expressly appointed to the purpose of regulating the thickness of the silken fibre with which the cocoons are formed; they are a provision of Nature which determines the thickness of the silken thread, and that thickness, in worms of equal size, will be constantly uniform, so that a large and healthy worm will yield a thicker fibre than a smaller and degenerated worm.

As long as the reservoirs contain gum, the thickness of the silk will be the same whether the worm is diseased or not, provided

* Journal Soc. Arts, Nov. 6th, 1863, p. 776.

always that the worms are of equal size; and that simply owing to the regulating organ above mentioned. The quality of the silk comprises thickness of fibre, tenacity and elasticity, and where the secreting glands are not affected by disease, this quality, from worms equally well fed, will be the same even where the general health of the one is far inferior to the other; indeed it is the quantity, rather than the quality, of the silk that is affected by the maladies under which the worms are now labouring. The cocoons reared in Oudh by Colonel Clark, and pronounced by Mr. Cope, *in epistolâ*, to be "the finest he had seen in India," produced, on being reeled, a silk of precisely the same quality as that produced at Umritsir, and by my Mussooree cocoons reared from Mr. Cope's supply of diseased eggs in 1862, and which, as cocoons, were absolutely worthless, there being little or no silk in them. Dr. Bonavia's cocoons, raised in Oudh in 1863, from seed furnished by Mr. Cope, yielded a silk in no respect inferior to the above, although the pound of silk requiring 5,200 cocoons to produce it proved how terribly deficient was the quantity of gum secreted. In cases where the glands are affected by disease, or where the leaf has not contained a proper proportion of silk-yielding matter, no silk at all will be secreted, and the worm will either die as such, or become a pupa without spinning. Many cases of this kind occur in all the broods, whether monthly or annual.

To talk, as some do, of coarse leaves producing a coarse silk, and therefore recommending the use of such as are thin and tender, is at once to prove non-acquaintance with the anatomy of the insect and ignorance of the whole art of nourishing the worm, since, as already pointed out, the thickness of the silk fibre is regulated by Nature, and a thin fibre produced by a worm, which, like *B. Mori*, ought to yield one of a certain thickness, is a positive proof of the presence of disease, inasmuch as it indicates the decreasing size of the orifices, consequent on the deterioration and degeneracy of the worm. The orifices in the lip being of a regulated size, no extra-natural coarseness of fibre can be produced, and no coarseness of leaf could ever make the fibre thicker than Nature intended it to be, or than those orifices were capable of admitting, simply because it is a well-ascertained fact that "a camel cannot pass through the eye of a needle."

*Remarks on "the Diet of Worms."*

Having been frequently applied to from different quarters for information as to the best kind of mulberry leaf on which to rear the silkworm, it may be as well perhaps to give the result of my

own experience, and leave each inquirer to please himself as to the species he may find it most convenient and most suitable to adopt.

The question then is, "what species of mulberry tree is best adapted for the nourishment of the silkworm, and for the production of good silk?"

Were all climates alike the question might be easily answered, but in its present form it is too vague and general; besides which, thus put, it assuredly implies a belief that we have only one species of silkworm under cultivation, and that whether monthly or annual, all come under the head of *Bombyx Mori*. This, however, is not the case, the name of *B. Mori* belonging of right to the worm known in India as the Cashmere worm, which is an annual, and is cultivated in Afghanistan, Bokhara, Persia, Syria, Italy, France and other European countries. It was originally brought from the northern provinces of China, where the country is mountainous, and the climate, especially in winter, very severe and cold. There is also another worm cultivated as an annual in Bengal under the native name of *Boro-pooloo*, which means "large cocoon," it being the largest species of *Bombyx* under cultivation in Bengal. As compared with the cocoon of the Cashmere worm, however, it is very much smaller, of a different form and texture, and yielding generally a pure white silk, although, as already observed, in the colder temperature of Mussooree the yellow cocoons are at least quite as numerous as the white. This likewise is from China, and from its being an annual is supposed, with good reason, to be a native of the northern parts of that country. This species I have named *Bombyx textor*, as it is totally distinct from the Cashmere worm.

Three other species domesticated in Bengal are respectively termed the Madrassee or Nistry,—the Dasee,—and the small Chinese monthly worm; these three are termed monthly worms because they yield from six to eight crops during the year. These I have respectively named *Bombyx Cræsi*, *B. fortunatus* and *B. Sinensis*, while from the fact of their yielding several crops a year I am inclined to regard them as belonging to the warmer and more southern parts of China, the number of broods indicating a climate in which food is abundant throughout the year, while the annuals on the contrary, as every naturalist is aware, indicate a far more temperate climate.

Besides these there is said to be another species cultivated in Arracan which yields a silk superior to that of the Bengal worms, but as I have been hitherto unable to procure it for examination,

I can do no more than indicate its existence and name it provisionally as *Bombyx Arracanensis*.

Seeing, then, that this diversity exists among the worms, it is but reasonable to infer that in their native countries and in a state of nature, they did not all feed upon the same species of mulberry leaf, but that the annuals, like the wild *Bombyx Huttoni* of the Western Himalaya, were originally restricted to the trees indigenous to the cold mountainous regions of the north of China, while the monthly worms were in like manner confined to species adapted to the greater heats of the southern lowland provinces.

The question, then, as to which is the tree best adapted, in India or elsewhere, for the production of good silk, although apparently a very simple one, is in reality not easily answered, since much must depend upon the species of worm under cultivation, as well as upon the climate itself, and the difficulty is enhanced by the fact that every one who, possessed of much zeal but little knowledge of the subject, essays to rear silkworms, appears to think it necessary to extol some particular species of mulberry, and to pronounce it, for the time, the very *ne plus ultra* of silkworm diet.

One while it is the white-fruited mulberry only that can enable the insect to elaborate good silk, and anon, for some inexplicable whim, the white is discarded and another tree adopted in its stead. The purple-fruited species are unhesitatingly denounced, and to be "condemned without benefit of clergy."*

And yet the white mulberry is found to be nothing more than an Albino variety of the purple-fruited tree.

Count Dandolo long since pointed this out; and I have myself sown the seed of the dark purple mulberry, known to the natives as the "*Siah Toot*," and found that several of the young plants produced therefrom eventually bore white fruit only, the shape and flavour being entirely changed, and in some respects the leaf also. To my surprise, moreover, three young trees, said to be from Cashmere, and which for the past three years had borne white fruit alone, were this season (1863) covered with purple fruit.

The difference in the quality of silk reared respectively upon these two kinds—which are thus in reality not two, but one and the same—must be to a very great extent purely imaginary, and I will venture to assert that if two skeins of silk thus grown, that is to say, the one from the purple and the other from the white-fruited tree, were placed before any cultivator in India, he would not be able to distinguish between them.

* Proc. Hort. Soc. of India, 10th August, 1859, vol. xi. part 1, p. 64.

Of the *Morus alba*, Count Dandolo remarks,—"This species comprises the common wild mulberry, which has four varieties in the fruit—two have white berries, one red and the other black."

Here, then, the merest tyro may perceive that the red berry merely forms the connecting link between the black and the white fruit, and consequently that there can be but little, if any, difference in the quality of the leaf; indeed, all that the Count ventures to observe on the subject is, that "the leaf of the black mulberry, hard, harsh and tough, which is given to the silkworms in some of the warmer climates of Europe, in Spain, in Sicily, in Calabria and in some parts of Greece, &c., produces abundant silk, the thread of which is very strong, but coarse. The white mulberry-leaf of the tree planted in high lands exposed to cold dry winds and in light soil produces generally a large quantity of strong silk of the purest and finest quality."

Now, if by the term "coarse," as here applied to the silk raised from the black mulberry, is meant *thick as to fibre*, the difference is seemingly of little importance, and would be overcome, I should imagine, in the reeling by assigning fewer fibres to the thread; while that the produce of the white mulberry is not uniformly the same or to be depended upon is shown in its being only "generally," and not always, of the finest quality; and moreover "the finest quality" does not necessarily imply *thinness of fibre*, but may refer to other qualities, such as evenness, tenacity and elasticity; while, with regard to the degree of coarseness above alluded to, it must be borne in mind that it could not possibly be coarser than nature intended it to be, because the regulating orifices in the lip would prevent it. Besides which it is extremely questionable whether "high lands exposed to cold dry winds" and with a "light soil" are suitable to the mulberry tree, especially in such high latitudes; and if not, then the worms fed upon the leaves of such trees would be naturally less healthy and of smaller size than those reared under more favourable circumstances, and, consequently, the worm and the labial orifices being smaller, the silk would of necessity be finer. This, however, is not an argument in favour of the white mulberry, but against the locality in which it is grown. Seeing then that the silk cannot be coarser than nature intended it to be, while it may be much finer, the argument tends altogether to prove that great fineness of fibre is a consequence of decreasing size in the worm, produced by increasing debility of constitution.

M. Boitard, a French writer on the cultivation of silk and of the mulberry tree, informs us that the white mulberry is often tinged with red, a statement which upholds and confirms my

remark that the red holds an intermediate place between the black and the white fruit.

In 1858 the white mulberry appears in some quarters to have fallen in estimation, and the *Morus multicaulis* was likewise condemned, as it was said, "because it produces so few leaves, though they are larger, and partly because those few are too soft and milky for the worm, yielding a weak fibre."*

This statement, however, unfortunately proved to be an egregious blunder, the tree thus denounced being in reality not the *Morus multicaulis*, which, as the specific name points out, instead of having few leaves of large size, has a multitude of branches thickly covered with a moderate-sized leaf. The large-leaved tree is now named *Morus cucullata*, from the leaf taking the form of *a skull cap*, and strange to say, although pronounced to be worthless when supposed to be *M. multicaulis*, was subsequently, by the same authority, and under the equally erroneous name of *Morus Sinensis*, extensively cultivated as a first-rate silkworm diet.

Whatever may be the value of *M. multicaulis* and *M. cucullata* in their own native climates, they do not appear to have given much satisfaction elsewhere, and certainly in a cold northern climate they can scarcely be expected to do so; at Mussooree, I regard them both as trash, and although in Oudh, Dr. Bonavia found that *B. Mori* and *B. Sinensis* both ate them readily enough, yet in the later stages of the worm a leaf of greater substance was required. In such case I would recommend the coarser leaf from the very beginning, for if the young worm lacks sufficient nourishment in the two first stages of its growth, it will be next to impossible, by any amount of subsequent good feeding, to recover the ground thus lost.

It is, I am convinced, precisely because in the early stages the worms have been fed upon chopped and thin watery leaves, that the constitution has been at length brought to the very extreme of weakness. Starvation in childhood is surely not the best method of eventually producing either a strong healthy man, or any other animal!

The climate, the tree, and the species of silkworm to be reared should all, as much as possible, be adapted to each other; whereas under the present system the cultivator appears to think that climate, food and the constitution of the insect are all mere secondary considerations to be set at naught, and dis-

* Journ. Hort. Soc. of India, vol. x. part 2, p. 182.

regarded with impunity, and then wonders, because he has steadily pursued certain stereotyped rules, at the failure of his speculation.

Lest, then, this blind laudation of certain species should lead to mischievous results and disappointment among those who are desirous of entering into the speculation, I shall here beg leave to call the attention of the sericulturist to the well-known fact, that "what is one man's meat is another man's poison," and remind him that the diet which is admirably adapted to keep up animal heat and to nourish an individual in the vicinity of the North Pole, will be found both unsuitable and highly injurious to health in lower and warmer latitudes. We have but to cast a glance around us in order to perceive that each nation, according to its climate, differs somewhat from another in the matter of food; those of the warmer parts of the world being more frugal and less gross in their diet than those of the colder regions. Is it not proverbial, that where a Frenchman, content with thin wines and a few field herbs wherewith to make a salad, would thrive, an Englishman, addicted, as he is, to strong ale, with an unlimited allowance of beef and bacon, would starve outright? The raw seal blubber, so palatable to the Esquimaux, would be wholly unsuited to the more temperate countries of Europe, and, as a rule, we find that the diet is the simplest in the hottest regions, and becomes gradually more gross as we approach the north, where the cold requires the use of more solid and stimulating food to promote and keep up the animal heat of the body.

Something of the same kind is assuredly perceptible also among the feral tribes; the bears, for instance, being far more carnivorous in high latitudes than near the tropics, where fruits, vegetables and insects constitute the animal's food; but confining my remarks for the present to the larvæ of the *Bombycidæ* or silkspinners, we find that nature has ordained that the species in different latitudes shall feed upon different trees.

It may be said that this arises from the fact that the same trees are not found in these different localities, and consequently that the insects are compelled to seek another food, or to starve; this, however, does not appear to disclose the true philosophy of the question, and it certainly does not prove that such food in southern regions is equally stimulating with that of northern climes, but rather that instinct teaches the insect to accommodate itself to the provisions provided for it, precisely as a traveller to the northern regions makes use of pemmican, which he discards

on returning home. There are indeed not wanting proofs that even where the food of one latitude exists in another, the insect will refuse to eat it, as if aware that it is no longer suitable to its wants! The truth seems to be this, that where a tree and an insect have existed together in, perhaps, a southern latitude, and the tree ceases to grow in some more northern locality where the insect is still found, it is because the tree in the colder locality would no longer be able to furnish a sufficiently stimulating diet, and is, therefore, replaced by one more suitable to the wants of the insect. And this after all is simply one of those wise provisions of nature whereby her productions and the conditions under which they exist are mutually adapted to each other.

As a proof of this, we find that although the larvæ of the beautiful *Attacus Atlas* are known in Kumaon to feed freely and principally upon the leaves of the yellow-flowering barberry (*Berberis Asiatica?*), called at Mussooree *Russote*, yet with us, where the plant is equally common, I have never yet succeeded in inducing the worm to touch it, nor have I ever found either the larvæ or the cocoons upon this shrub. And yet out of forty-six cocoons now before me from Kumaon no fewer than forty-three have been spun among the leaves of *B. Asiatica!* Surely this looks like a case in point; besides which it is an unquestionable fact that among the mulberry trees which are known to be true species, and not mere varieties, the leaves of those from the north possess far greater thickness, consistency and nourishment than those from the tropics or warm lowland provinces. Take for example the leaves of *Morus multicaulis* and of *M. cucullata*, as compared with those of *M. Sinensis*, *M. nigra?*, and the wild indigenous trees of the North Western Himalaya.

At Pondicherry, according to information derived from my obliging correspondent M. Perrottet, the *Actias Selene* is entirely restricted to the *Odina Wodier* of Roxburgh, while at Mussooree it is polyphagous, feeding on *Coriaria Nipalensis*, *Carpinus bimana*, *Andromeda ovalifolia*, *Cedrela paniculata*, the common walnut, *Cerasus puddum*, or wild cherry, *Pyrus variolosa*, and several others. Again, *Attacus Cynthia*, which in China is nourished on the leaves of *Ailanthus glandulosa*, feeds in Cachar upon a tree called "*Lood*," and at Mussooree on *Coriaria Nipalensis*, *Xanthoxylon* hostile* and some others; and so on, indeed, throughout the family.

* In previous papers this word has invariably appeared as *Xanthophyllum*, which is an error.

The wild indigenous mulberry of Mussooree, with thick coarse leaves full of milky juice, is often so thickly covered with the larvæ of *Bombyx Huttoni*, that by the beginning of May there is not a single leaf upon the tree wherein the worm can spin its cocoon; yet although the thinner-leaved cultivated mulberry may abound in the immediate neighbourhood, it never by any chance experiences the same treatment; so that taking the hint from nature, I am inclined to recommend for the *Bombyx Mori*, when cultivated in the upper provinces, and more especially in the hills, such leaves as those furnished by *M. nigra?*, *M. Sinensis*, *Bédana* or seedless long white mulberry, and others of the thick rough-leaved kinds.

At the same time it is highly probable that certain species, which are wholly unadapted to a cold hill climate and the action of severe frost, may thrive well in the lowland provinces of India, where they will likewise be suitable to the worms of warm localities, such as I consider the Bengal monthly worms to be. But to extol in general terms one species above another, and endeavour, on wholly insufficient and often purely theoretical data, to persuade people that it is the best adapted for the nourishment of the silkworm,—the species of worm, moreover, not being specified,—is, in my opinion, the surest way of propagating pure sophistry and of insuring the failure of speculations in other districts, which, from the nature of their climates, require both a different diet and a different mode of treatment.

There is, moreover, yet another point to be considered, for although certain trees, such as *M. multicaulis* and *M. cucullata*, may thrive well enough in the Punjab and the Gangetic provinces, yet it is more than doubtful whether the Cashmere worm will thrive upon them; for while the trees delight in and are adapted to a warm lowland temperature, the insect, whose cultivation is becoming fashionable in the upper provinces, is from the northern mountainous tracts of China, situated between 32° and 34° of north latitude, whereas in our Himalayan regions frost and snow are the accompaniments of winter. The cultivator should remember that a northern insect requires a northern tree, and the northern tree requires a northern climate, and that he himself requires a certain amount of knowledge and the exercise of common sense.

Trees producing leaves of extreme thinness, like those of *M. multicaulis* and *M. cucullata*, are far from desirable on account of their containing but little nourishment, and necessitating a larger

and more frequent supply. A good and healthy leaf should contain the four ingredients of fibre, water, saccharine and resinous matter; the two first go directly to the nourishment and growth of the worm, while from the two latter is secreted the supply of gum which eventually furnishes the silk. Where the two former only are found, or where they are greatly in excess, as is sometimes the case, the worm will grow and attain to a goodly size, but will produce little, or perhaps no, silk. In breaking off a good healthy leaf, a drop or two of thick milky viscous juice should exude from the stalk, and in this resides the silk-producing matter; the *Morus Sinensis* and all the thick-leaved trees possess this in far greater quantity than either *M. cucullata* or *M. multicaulis*, and indeed from the latter species, when grown in a cold climate, it is almost absent, being thin and watery.

Yet after all, it has long since been laid down as an ascertained fact, that however much *the quantity* of silk may be dependent upon the presence of this juice, *the quality* is far less dependent upon the good properties of the leaf than upon the temperature in which the worms have been reared; so that where this is higher than the constitution of the insect is fitted to endure, no matter how well it may have been fed, the yield will always be inferior to that produced in a more genial temperature; and that the *Bombyx Mori* of Cashmere is greatly influenced even by the heat of the Punjab, is proved beyond all contradiction by M. Perrottet's observation, *in epistolâ*, that eggs deposited there and sent to him by Mr. Cope, of Umritsir, were inferior in size, and far more irregular in form, than those sent by me from Mussooree, where the climate is better adapted to the species. The fact is moreover fully established by the annual loss sustained by Jaffer Ali as above narrated, as well as by Mr. Cope's expressed intention of sending his Punjab-bred eggs to the hills during summer, and of importing annually fresh seed from Cashmere. The same remark is equally applicable to Oudh.

That the thinness of the leaf, both in *M. multicaulis* and *M. cucullata*, is a very serious defect may be gathered from Count Dandolo's remark, that "the less nutritive substance the leaf contains, the more leaves must the silkworm consume to complete its development. The result must, therefore, be that the silkworm which consumes a large quantity of leaves that are not nutritive, must be more fatigued and *more liable to disease* than the silkworm that eats a smaller proportion of more nutritive leaves. The same may be said of those leaves which, containing a sufficiency of nutritive matter, contain little resinous substance; in that case

the insects would thrive and grow, but probably would not produce either a thick or strong cocoon proportionate to the weight of the silkworm, as sometimes occurs in unfavourable seasons. My experiments," continues the Count, "prove in the ultimate analysis that, all things balanced, the qualities of the soil produce but a very slight difference on the quality of the leaf; that which will appear most evident is, that the principal influential cause of the fineness of the silk is the degree of temperature in which the silkworm is reared. It is neither the water nor the fibre of the leaf that nourishes the silkworm and renders the cocoon heavy, but *the resinous and saccharine substances.*"

The concluding sentence, however, is scarcely to be relied on, since the worm in its growth is undoubtedly nourished by the water and the fibre of the leaf, although it is equally true that the weight and thickness of the cocoon depend upon the presence of the other substances, while it is necessary to guard against the error of endeavouring to produce too much fineness in the silk, since I have already shown that to be an indication of too high a temperature and of the consequent degeneracy of the worm. Besides which, that the soil must in some measure act upon the quality of the leaf can scarcely be doubted when we consider that it is from the soil that the tree derives its nourishment, and the changes which occur both in the shape and substance of the leaf and in the colour of the fruit can be attributed, I imagine, to nothing else.

In regard to the treatment of the trees, it has been justly remarked that they may be very seriously injured by too close plucking; it has been forgotten, however, by those who in India have laid some stress upon the fact, that the remark applies rather to the mulberry trees of Europe and other temperate climes, than to those of tropical regions; for in the former there is too short a summer to enable the tree to produce fresh leaves without an injurious effort on the part of Nature;* whereas in tropical and neighbouring climates, where the summers are warm and long, and otherwise conducive to the growth of vegetation, the dread of injury need scarcely be entertained. Nature, indeed, herself points out that such is the truth, for in the Himalaya the indigenous mulberry trees may often be seen in the early part of May without a single leaf upon them, all having been devoured by the first or spring-brood of the larvæ of *Bombyx Huttoni;* and yet in

* Mr. F. Moore informs me that eggs of *B. Huttoni* hatched in April, when there were yet no leaves!

about three weeks afterwards, or even less, the same tree will be found to have again put on an abundant and healthy foliage ready for the second or autumnal brood of the same worm. This sometimes goes on year after year without the least apparent injury to the tree, and even the cultivated kinds are often stripped of every leaf and berry by the monkeys (*Semnopithecus schistaceus*), and yet put forth a second crop of both. What, therefore, Nature does, man may surely, in similar situations and under similar circumstances, imitate with like success.

Many things, indeed, in regard to the rearing of the silkworm, have passed into laws without the persons who adopt them having the slightest notion why they have done so, or even caring to reason on the subject;—thus we have one law forbidding more than a certain degree of denudation of the foliage, which is strictly applicable to northern climates only, and necessitates the planting of an additional number of trees. Then, again, another law enjoins that no moisture must remain upon the leaf for fear of injury to the worm; and yet in a state of nature we must feel assured that the leaves are often wet with rain and dew without doing injury to the worms that feed upon them; why then are they injured when in a state of domestication? Simply because Nature always feeds her worms with the best and freshest leaves, and in that state no injury ensues, as I indeed have often proved even with domesticated worms; but if the leaves, as is too generally the case, from being closely packed, brought from a distance in the heat, and kept for hours before they are given to the worms, have begun to fade and lose their natural freshness, the moisture on them, by imbibing the exhaling gasses, will act as an active poison on the worm and kill it.

Again, where the temperature of the rooms can be kept down to 80° of Fahrenheit, it is obstinately asserted that the constitution of the worm cannot suffer; yet such reasoners forget that in a warm climate they can only keep down the temperature by shutting up the house and excluding heat, and that in so doing they cause malaria to arise among the worms and ordure by the exclusion of every breath of that pure fresh air which is so essential to the insect's healthy existence.

Lastly, chopped leaves must likewise be compassionately given to the new-born worms, for fear the hardness of the leaf should *hurt their gums*, and give the tender brats *the tooth-ache*.* Not a

* Journ. Hort. Soc. of India, vol. x. part 2, p. 182.

breath of wind, not a change of temperature, must pass over these tender beings, for fear the destroying angel should stretch forth his hand and ruthlessly exterminate the whole. But common sense would fain inquire,—"Is the worm naturally of so tender a constitution that no change must be suffered to come nigh its dwelling? If so, how did the insect contrive to brave the storms, and outlive the daily changes of temperature, even from day to night, when exposed upon the trees in its own native and northern mountain climate? Nay why was such change from day to night ordained if it were to prove injurious to organic structures?"

I have proved, however, at Mussooree, that the worms of different species, even in their present debilitated state, are not so delicate as it has hitherto been the fashion to suppose, and have successfully reared great numbers of worms that were night and day exposed to every change of temperature, to every gale that blew, and above all to the constant moisture of the mists which were permitted to pass through the room, saturating leaves and trays, and causing the worms themselves to sparkle through the moisture deposited upon them. Yet notwithstanding this rough treatment no deaths occurred, no particular diseases showed themselves, and the cocoons produced were pronounced by competent judges to be good and the silk of the best quality.

They have likewise been successfully reared in France in the open air, and the cocoons are pronounced to be superior to those reared within the house.

And yet, after all, seeing that the constitution of the insect has been completely destroyed, what wonder if it be found unable to bear up successfully against the sudden changes of temperature of a foreign climate? Too great a degree of heat,—an improper system of feeding,—the exclusion of fresh air from the rooms, and, above all, the long-continued system of breeding in and in with debilitated stock, have at length reduced the worm to the condition of a *leper*, and have banished from its skin every trace of those colours with which Nature had originally ornamented it. Even in Europe it has been found that heat is inimical to its health, for not only in Italy is the best silk produced in the mountainous parts of Piedmont, but M. Guérin-Ménéville, in a tour made in 1858 through France and Italy, likewise declares that it is in "those elevated localities where the vine and the mulberry escaped disease, that the worm was found to enjoy the best health."

This indefatigable naturalist also notices a custom which has

long struck me as being most objectionable, and one which has most certainly contributed in no slight measure to destroy the strength and healthiness of the worm. "Nature," observes M. Guérin-Ménéville, "distinctly shows that it is her wish that the sexes should remain coupled for a certain time, and that time is generally from ten to twelve hours, and often more."

Yet, notwithstanding the truth of this remark, it has become the custom, after Count Dandolo, whose opinions are not always to be depended on, to separate the sexes at the end of five or six hours, and the unavoidable consequence is, that while half the eggs remain altogether unimpregnated and wasted, the other half will produce weakly and sickly worms. It naturally follows then, from this unnecessary interference with Nature's mysteries, that the worms produced are pre-disposed to disease, and as this goes on year after year, and has done so for centuries past, of course the worm becomes more and more degenerated and debilitated.

Surely even here a useful lesson may be learned from the proceedings of the wild species, since every one who has tied out the females of any of the larger *Bombycidæ*, such as *Antheræa* or *Attacus*, must have observed that the wild male found coupled with the female in the morning, will, if unmolested, remain so until after sunset, when a voluntary separation takes place.

*Conclusion.*

That matters, as regards the silkworm, are in a very critical and unsatisfactory condition, is fully acknowledged by the French cultivators, but I very much doubt if they have adopted the best means of checking the various maladies with which the insect is beset. Quacks, doubtless, will be found in numbers ever ready to extol some secret nostrum, but the remedies hitherto applied to cure particular phases of disease are calculated to exercise but a temporary effect, and do not by any means strike boldly home and remove the causes from which the maladies arise; hence in 1861, it was feared that the yield of silk throughout all France would scarcely rise to one-half the return given in previous years. Perfectly useless is it to seek in foreign lands for a healthier and more vigorous seed, since the loss of constitution is universal, and I confidently aver that nothing short of the re-discovery of the insect in its original state of nature, or of the complete restoration of the constitution of the domesticated stock by causing the worm *to revert* to its pristine colour and characteristics, will ever be able to avert the doom which now appears to be impending over the whole domestic stock of *Bombyces*.

The mode of doing this is as simple as could be wished. Nature, ever watchful over the welfare of her productions, herself points out the course to be pursued, and invites us to profit by her wise suggestions, when she gives us so broad a hint of the true state of affairs as to place before us in almost every brood of domesticated worms a few dark individuals, as if for the express purpose of attracting and fixing the naturalist's attention, and compelling him to adopt a method of perpetuating that dark race. Let the sericulturist separate these from his general stock, and set them apart for breeding from; let him annually weed them of all pale-coloured worms, and in the course of three or four years he will be enabled to cast aside his present sickly colourless stock, and rejoice in the acquisition of a worm far healthier than ever it has been since the day when it was first imported from the east by the enterprising monks to whom we are indebted for its introduction into Europe.